General Information

Report 32

Review and development of energy efficient refurbishment standards for housing associations

BEST PRACTICE PROGRAMME

Energy Efficiency

DEPARTMENT OF THE ENVIRONMENT

THE HOUSING CORPORATION

BEST PRACTICE PROGRAMME

Review and development of energy efficient refurbishment standards for housing associations

Contents

SUMMARY

BACKGROUND

The purpose of the project, funded by the Department of the Environment and the Housing Corporation, was to explore the opportunities for incorporating energy efficiency measures into planned improvement works of repair and refurbishment.

The study aimed to establish if current housing association specifications for refurbishment work could include more energy efficient and cost-effective measures. The use of energy ratings and affordable warmth, as a means of setting an energy target, was investigated. The study follows an earlier BRECSU project which investigated the cost of energy efficient upgrades for newbuild housing association dwellings. Best Practice publication Future Practice Research and Development Final Report 2[1] describes the project, following which in 1993 the Housing Corporation recommended a SAP target of 75 for new housing.

METHODOLOGY

Details of the proposed repair and refurbishment project were published in the housing and technical press, and housing associations invited to participate. From the 65 schemes submitted, 23 were selected to form a sample representative of age, type of improvement and size of association (see table 1). A total of 549 dwellings were included.

The Government's Standard Assessment Procedure (SAP) for home energy rating was used for each house type to assess the energy efficiency performance. Further more detailed analysis using the BRE Domestic Energy Model (BREDEM) was undertaken to assess the cost-effectiveness of the individual energy saving measures included in the associations' specifications. The housing associations were then given details of this analysis, together with recommended additions to, or omissions from, their proposed specification. The associations were asked to supply actual costs of energy efficiency measures from successful tenders. Finally, sites were visited to obtain any outstanding information and to check buildability issues.

RESULTS

The original specifications proposed by the associations generally achieved a good standard of energy efficiency. The average SAP rating for the dwellings was increased from 31 to 72, following a full improvement package of modernisation or refurbishment. Furthermore, about 75% of all the improved dwellings achieved a SAP rating of 65 or more. About 30% of the dwellings achieved a SAP rating of 75 or more, the 'newbuild' target at the time. These ratings indicate the high level of specification adopted by most housing associations and compare well with typical SAP ratings of 65 to 75 for dwellings built to the 1990 Building Regulations thermal standard. In fact, this was widely used by many housing associations as a refurbishment target.

Although housing associations improved thermal performance in order to provide affordable warmth for their tenants, they saw energy ratings as a simpler and more easily definable and attainable target than 'affordable warmth' targets.

ENERGY EFFICIENCY MEASURES

During the study, packages of recommended energy efficiency measures were developed for four typical dwelling types: solid walled houses, solid walled flats, cavity walled houses and cavity walled flats. These packages are listed in Good Practice Guide 155[2] 'Energy efficient refurbishment of existing housing' and summarised in table 6.

A wide range of energy efficiency measures was adopted by the housing associations that participated in the study. Typical items recommended that went beyond existing specifications were gas condensing boilers, cavity wall insulation, and greater thickness of insulation for dry lining and hot water cylinders. Table 1 summarises the energy efficiency measures used in each scheme. In about half the cases, recommendations were made to improve the SAP rating of the proposed scheme by four points or more. In six schemes, it was recommended that some items be omitted because they were not cost-effective.

A number of energy efficiency techniques were viewed with caution by some housing associations. In particular, cavity wall insulation was not specified on two feasible schemes due to fears about rain penetration, and some associations were reluctant to specify condensing boilers until they had established a good track record for reliability. In contrast, insulated dry lining was widely used, but not always installed correctly. The continuous ribbon of adhesive at the wall perimeter, needed to minimise air infiltration, was frequently omitted on site.

GUIDANCE AND STANDARDS

Based upon this study and other BRECSU experience of refurbishment, Good Practice Guide 155[2] was published. It gives detailed recommendations on selecting a package of improvement measures, and includes comments on buildability issues and recommended sample specification clauses. The study has also led to the adoption by the Housing Corporation of new minimum SAP targets essential for funding of housing association refurbishment.

Housing association	Scheme name	Description of scheme	Heating fuel	Energy saving measures
SOLID WALLED HOUSES				
1 County Palatine	Glebe and Hope Street	Full refurbishment of three Victorian terraced houses – shared ownership	Gas	GCH IWI RI DS
2 North Sheffield	Oversley and Fife Street	Refurbishment of two mid-terraced Victorian houses with attics	Gas	CON GCH IWI RI FI LE DG PAS DS
3 Notting Hill	59 Shakespeare Road	Re-improvement of 3-storey semi-detached Victorian house	Gas	GCH IWI RI FI DG DS
4 Ridings	69/128 Spencer Place	Refurbishment of two 3-storey mid-terraced Victorian houses	Gas	CON GCH IWI RI DG DS
5 West Hampstead	Richborough Road	Refurbishment of two semi-detached Victorian houses	Gas	CON GCH IWI RI DG DS
SOLID WALLED FLATS				
6 Circle 33	22 Windsor Road	Re-improvement of 3-storey Victorian house divided into two flats	Gas	GCH IWI RI DG DS
7 Leicester Newarke	135 Upperton Road	Refurbishment and conversion of 3-storey Victorian house into 5 bedsits	Electricity	ESH IWI RI DG HRV DS
8 Notting Hill	15/16 Powis Square	Re-improvement of 11 flats in two large 6-storey houses	Gas	GCH EWI IWI RI DG DS
9 Peabody	Kent House	Re-improvement of 30 flats in 5-storey deck-access mansion block	Gas	GCH IWI RI (DG) (DS)
10 Wirral Methodist	The Copperfield	Conversion of two floors over listed pub (Living Over the Shop project)	Gas	GCH IWI RI DG DS
CAVITY WALLED HOUSES				
11 Haig	Haig Close, Bristol	Re-improvement of 24 houses in 1930s housing estate	Gas	GCH CWI RI DG DS
12 North (Cumbria)	Ennerdale Road	Re-improvement of 27 semi-detached houses in1950s estate	Gas	GCH CWI RI (DS)
13 North (Durham)	Shotton	Re-improvement of 60 semi-detached houses and bungalows	Gas	GCH (RI) (DS)
14 Shape	14/16 Wellington Road	Planned maintenance of two 1950s semi-detached houses	Gas	GCH IWI RI DG DS
15 Swaythling (Southampton)	Grange Farm Estate	Re-improvement of 62 houses and Estate bungalows built 1936 – 1952	Gas	GCH IWI RI DG DS
CAVITY WALLED FLATS				
16 Anchor	Balfour Road	Replanning and re-improvement of 28 flats in 2-storey 1970s block	Electricity	ESH RI DG DS
17 Beacon	Neville Court	Conversion and extension of 12 flats in 2-storey 1950s block	Gas	GCH (CWI) RI DG DS
18 Devon and Cornwall	Rose Duryard	Major repair to 60 flats in 1970s blocks over car park deck	Electricity	ESH (CWI) RI (DG) (DS)
19 Heantun	Mill Street	Major repair to 72 flats including new pitched roof	Gas	(GCH) CWI RI DG DS
20 MOAT	St John's Court	Modernisation of 12 bedsits in 2-storey 1970s block	Electricity	ESH CWI RI DG DS
21 Orbit	Regency Court Sutton	Major repair to 34 flats in 3-storey 1970s block	Electricity	ESH CWI (RI) (DG) DS WHRV
22 Swaythling (Portsmouth)	Farmside Gardens	Refurbishment of 84 maisonettes in 4-storey deck-access block	Gas	GCH IWI RI DG DS
23 Trident	Highgate Close	Conversion of 1970s former children's home into 7 flats for young singles	Gas	GCH (CWI) RI DG DS

Key to energy saving measures

GCH	Gas central heating	DG	Double glazing
CON	Condensing boiler	LE	Low E glazing
ESH	Electric storage heaters	DS	Draughtstripping
RI	Roof insulation	HRV	Heat recovery ventilation to kitchen and bathroom
FI	Ground floor insulation	WHRV	Whole house heat recovery ventilation
IWI	Insulated dry lining	PAS	Passive ventilation system
CWI	Cavity wall insulation		
EWI	External wall insulation		

Measures in brackets (eg (CWI)) were undertaken during earlier improvement work

Table 1 Summary of selected schemes

1 AIMS AND OBJECTIVES

The overall aim of the project on which this report is based, was to establish the opportunities for improving the energy efficiency of the existing housing association stock. This aim was translated into the following objectives:

- to identify planned improvement works
- to demonstrate the cost-effectiveness and practicality of an energy efficient approach
- to demonstrate how the Government's Standard Assessment Procedure (SAP) home energy rating can be a useful tool in establishing a cost-effective package of measures
- to advise the Housing Corporation on policy for setting energy efficiency refurbishment targets.

2 BACKGROUND

Over recent years there has been a steady rise in the standard of energy efficiency adopted by housing associations when modernising their housing stock. The motivation for this has been the desire to provide affordable warmth, and to limit energy use and CO_2 emissions in line with the policy objectives in the Government's White Paper, 'This Common Inheritance'.

This project was devised to explore whether current improvement methods adopted by housing associations could incorporate more cost-effective energy efficient techniques. It was jointly funded by the Department of the Environment and the Housing Corporation, and managed by BRECSU.

The study follows a successful Best Practice programme project carried out in conjunction with the National Federation of Housing Associations (NFHA) on energy efficiency in newbuild housing. As a result of this, Tony Baldry, the then junior Housing Minister, launched the final report and the EEO published a detailed technical Good Practice Guide[3] for designers. The Housing Corporation also set in 1993, for the first time, a minimum recommended energy efficiency standard for newbuild properties.

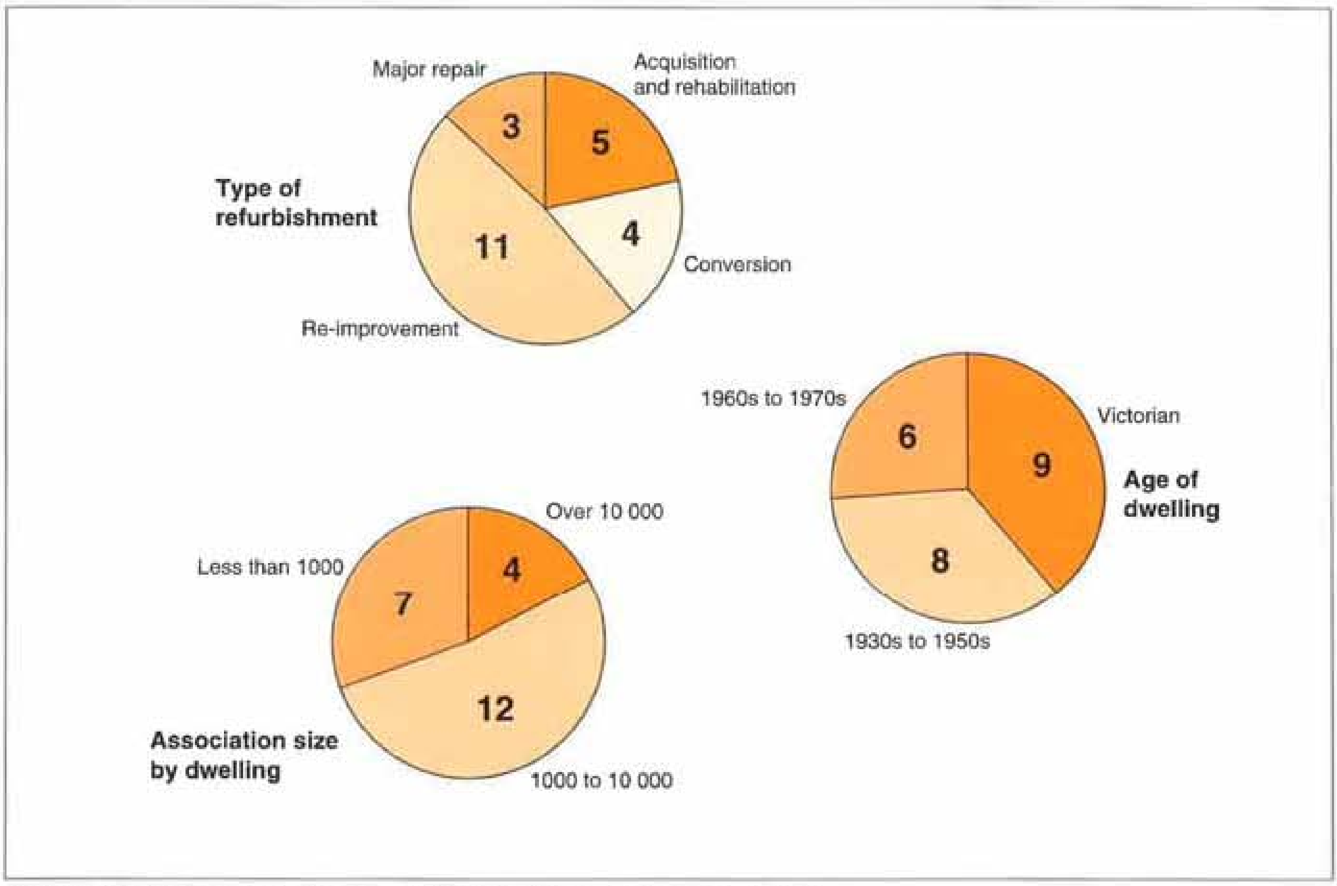

Figure 1 Distribution of schemes according to age, type and size of association

3 METHODOLOGY

3.1 Selection of housing association schemes

Details of the proposed project were published in 'Corporation News', 'Voluntary Housing', 'Innovations in social housing' and 'The Architects Journal'. Housing associations that responded to the invitation to participate were sent a single-page questionnaire in order to collect the basic information on each scheme.

From a total of 65 schemes submitted, 23 were selected (see table 1) to be representative of size of housing association, type of improvement and age of property, as shown in figure 1. Schemes were also selected from each of the Housing Corporation regions, with site locations shown on the map (figure 2). Most schemes were expected to go to tender in the first half of 1993. In all, 364 flats and 185 houses were included in the project.

The schemes covered the refurbishment, re-improvement and conversion of Victorian properties, the re-improvement and modernisation of 1930s and 1950s properties, as well as major repairs to 1960s and 1970s flats. One scheme involved the conversion of a former children's home and another, under the Government's 'Living Over The Shop' initiative, brought into use the two floors above a listed pub. The forms of contract included conventional bills of quantities, as well as design and build.

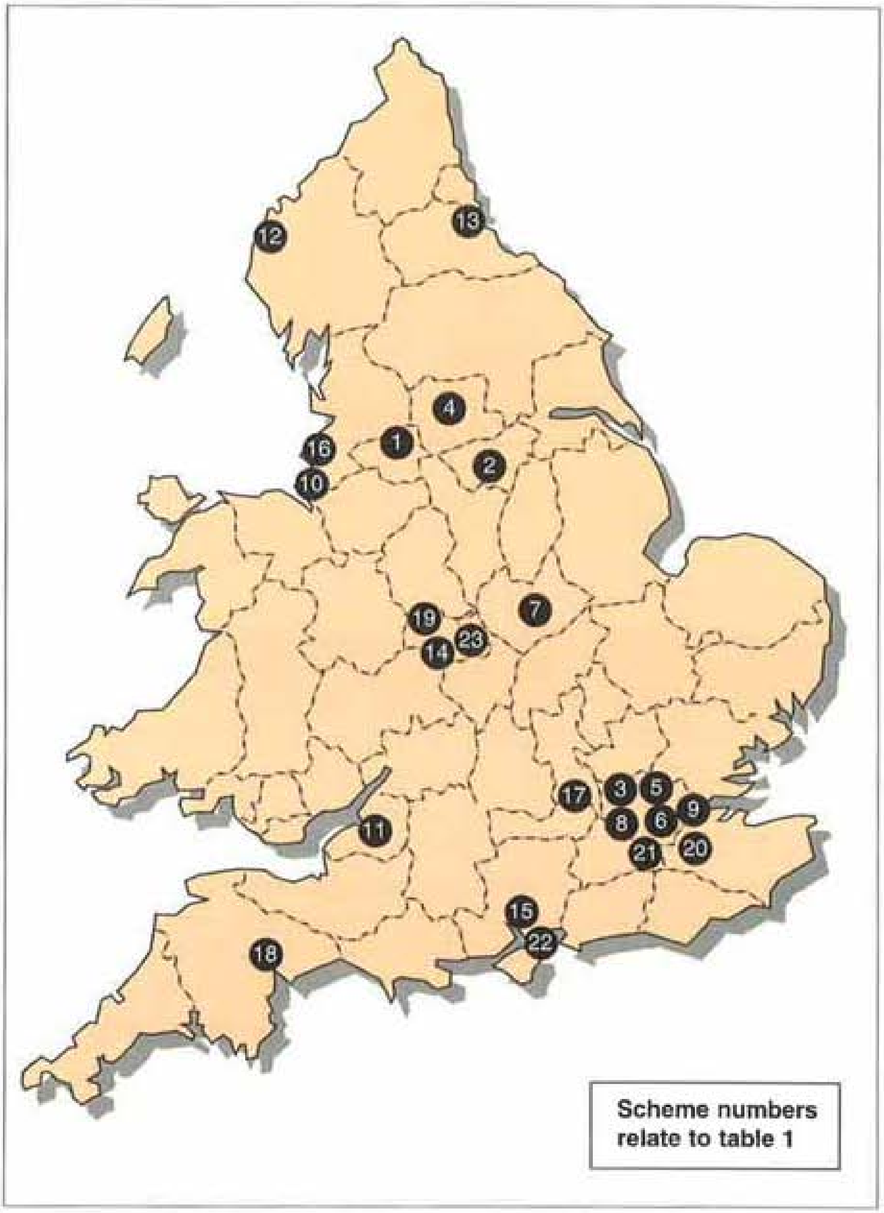

Figure 2 Map showing the location of housing association schemes

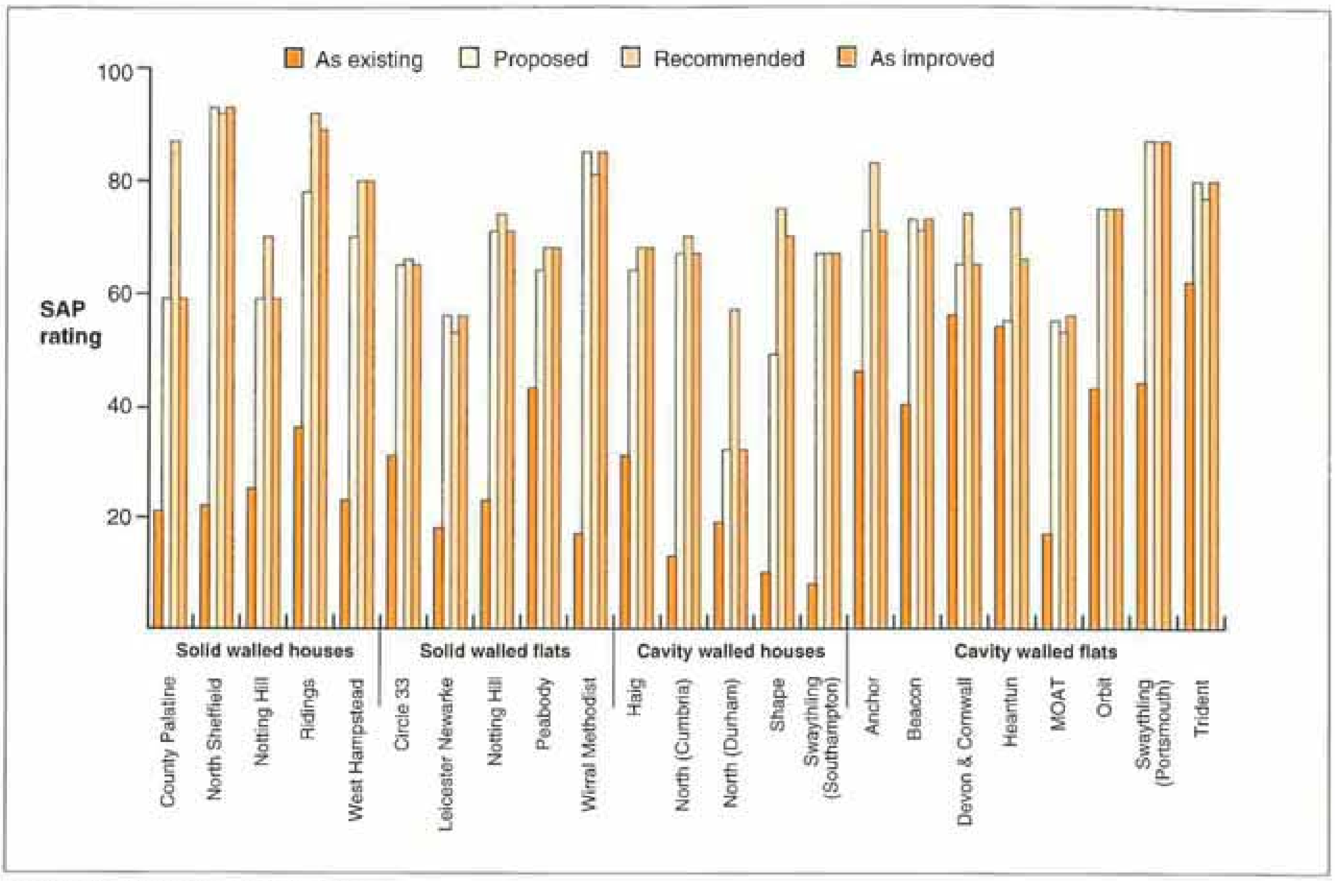

Figure 3 SAP ratings for each scheme

3.2 Analysis of the schemes

Housing associations supplied details of their proposed schemes, and typical dwelling types were selected from each one. For each dwelling type, a range of improvement options was investigated and analysed. SAP ratings were calculated, and annual heating and hot water running costs (and the associated CO_2 emissions) were estimated using BREDEM to determine the SAP energy rating.

For most schemes, a specification had already been prepared by the association or its consultants for the proposed work. Often this was a standard specification or the development of a previous one. In a few cases, the SAP rating and design analysis was done before finalisation of the specification.

Each dwelling type was analysed on a step-by-step basis, so that the cost-effectiveness of each improvement measure could be assessed separately. Further potential energy efficiency measures, not included in the proposed specification, were also investigated and their cost-effectiveness checked.

Housing associations were given details of the SAP analysis, together with any recommended changes to their proposed specification. Where no specification had been prepared, a package of measures was suggested.

3.3 Criteria used when recommending energy efficiency measures

Generally, energy efficiency measures were considered cost-effective if they had payback periods of 10 years or less for fabric measures, and 5 years or less for heating related measures (since lifespans are shorter for heating plant).

Certain measures were only cost-effective as a result of being carried out in conjunction with other work, such as:

- installing double glazing in replacement windows
- adding insulation when re-roofing a flat roof
- incorporating external wall insulation when cladding or rendering was necessary to prevent rain penetration.

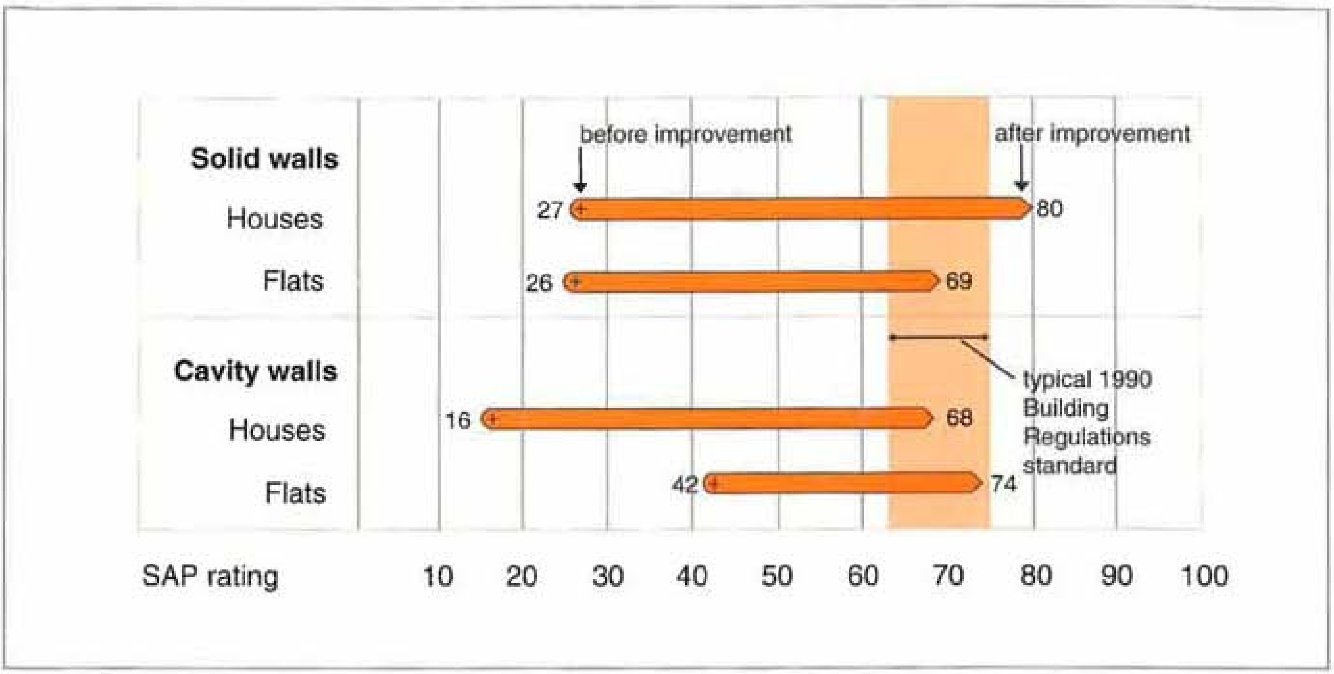

Figure 4 Average improvement in SAP rating for different types of dwelling and construction

4 RESULTS

4.1 The SAP analysis

Four SAP ratings were calculated for each scheme, corresponding to:

- the construction of the existing dwelling
- the specification proposed by the housing association
- the package of recommended measures
- the improved dwelling.

On average for the 23 schemes, there was an improvement from a SAP of 31 to 72 for the refurbished schemes (excluding four non-typical schemes that had single elemental improvements, such as central heating or flat roof repairs). This compares with typical SAP ratings of 65 to 75 for dwellings built to the thermal standards of the 1990 Building Regulations. The results of the SAP analysis for each scheme are shown in figure 3, arranged according to dwelling type. The average improvement in the SAP rating for each of the groupings, houses or flats with solid or cavity walls, is shown in figure 4, alongside typical ratings for dwellings built to the 1990 Building Regulations.

The low SAP ratings of the existing cavity walled houses (mainly 1930s to 1950s properties) can be attributed largely to their old and inefficient heating systems. In contrast, the higher SAP ratings of the existing cavity walled flats (mainly 1960s and 1970s) is largely due to their higher levels of insulation, compact plan forms and more modern heating systems. The relatively high SAP ratings of the refurbished solid wall houses can be attributed mainly to the use of condensing boilers in most of these relatively large properties.

The full range of SAP ratings for each individual dwelling is shown graphically in figure 5, in order of improved SAP rating. Most schemes contained more than one dwelling type. The relationship of a SAP rating for each individual dwelling to floor area is depicted in figure 6. This was used in discussions with the Housing Corporation to establish realistic SAP targets for refurbishment. Dwellings which have a full refurbishment package but a SAP rating of 60 or less are mainly small (less than 45 m^2), ground floor flats. Small dwellings which have a high proportion of external wall in relation to their floor area are difficult to cost-effectively refurbish to the same SAP ratings as larger dwellings. As a result of the improvement work, it was estimated that there would be a reduction in CO_2 emissions from an average of 8.8 tonnes per annum over all the schemes to 3.4 tonnes per annum. Figure 7 contains a summary of the CO_2 emissions for each individual scheme, before and after improvement.

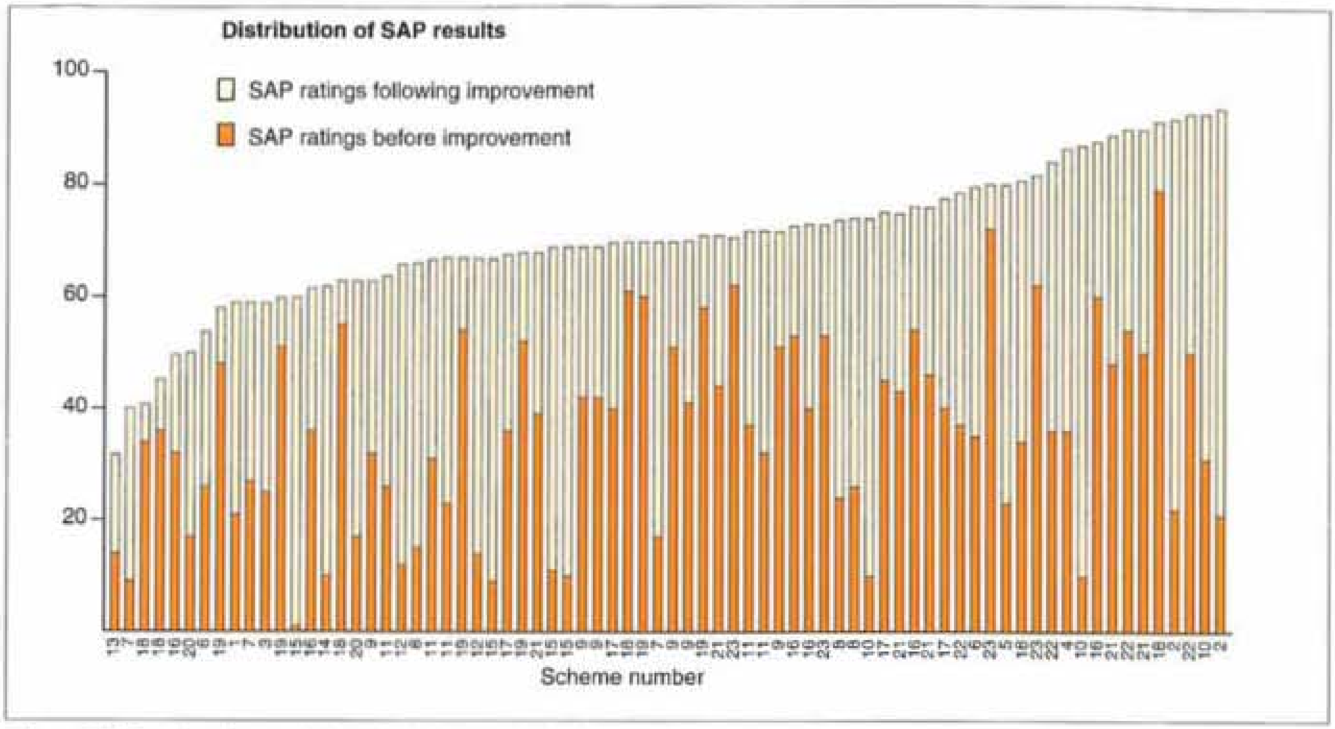

Figure 5 SAP ratings for each dwelling, before and after improvement

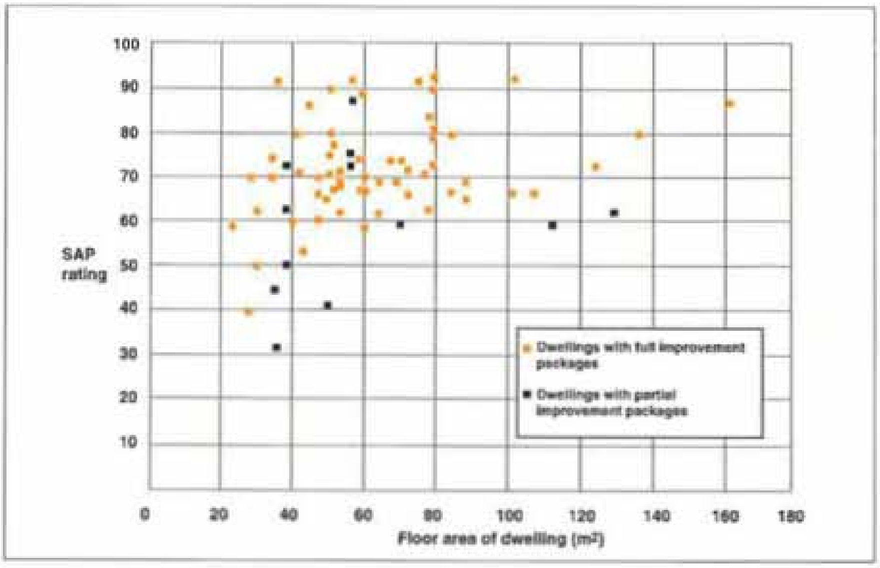

Figure 6 SAP ratings for each improved dwelling by floor area

4.2 Recommendations for improvement

The original specifications proposed by the housing associations generally achieved a high standard of energy efficiency. In about half the schemes, improvements were recommended that would raise the SAP rating by four points or more. Of these, three associations implemented most of the recommendations within the existing scheme. Five others planned to either improve future specifications or carry out further work in future phases. Table 2 summarises the main recommendations made for improving the energy performance of the dwellings.

For six schemes, the BREDEM analysis showed that some specification items (see table 3) were not cost-effective when seen from an energy standpoint. However, they were usually justified for other reasons, such as to reduce the risk of condensation, to improve radiant comfort or sound insulation, or to make full use of the opportunity presented by the refurbishment. There were several reasons why the recommendations were not always adopted by the housing associations on the schemes offered for this study.

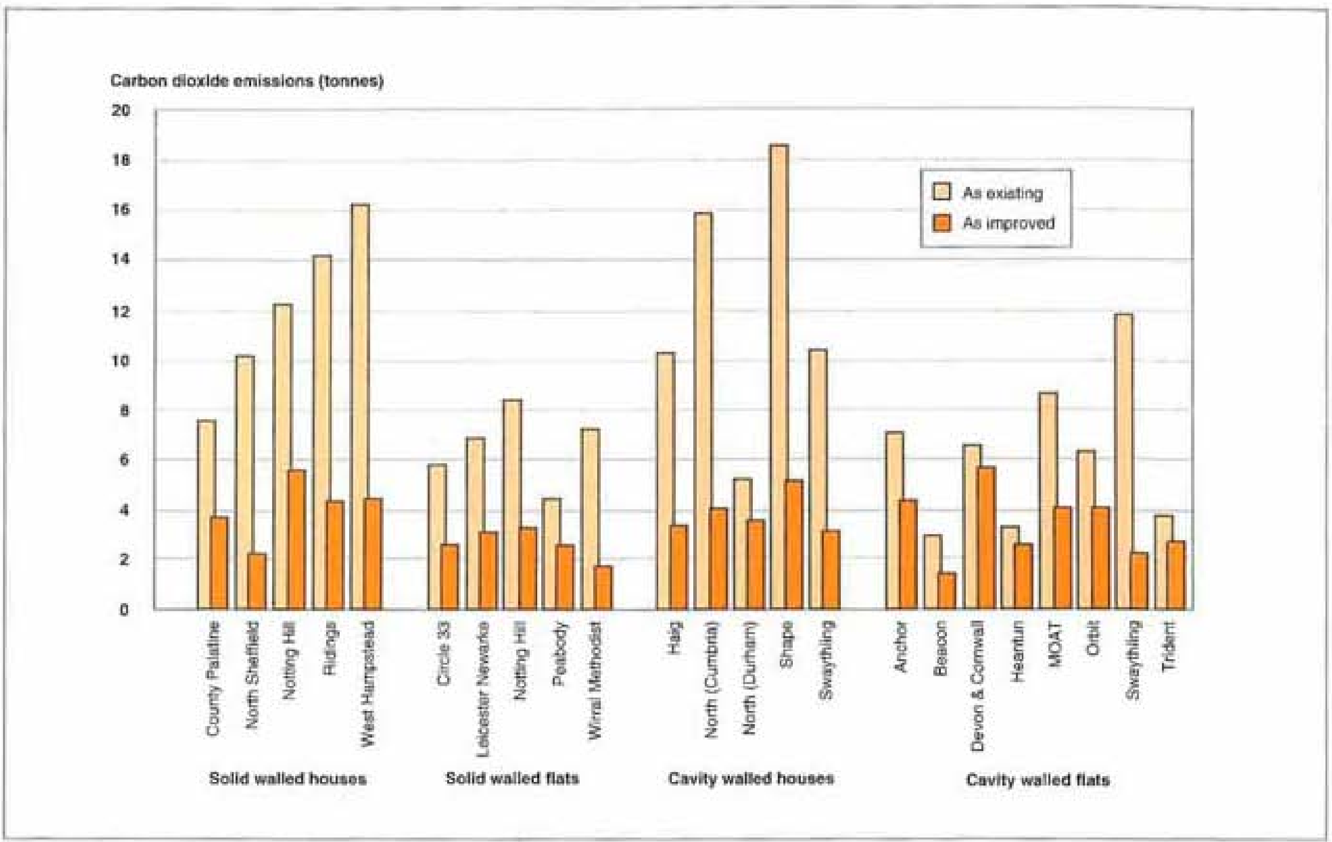

Figure 7 Carbon dioxide emissions by scheme, before and after improvement

The main one was that many contracts were already at an advanced stage when the BREDEM analysis was carried out, and housing associations were understandably reluctant to delay the tender procedure.

- Condensing gas boilers instead of conventional boilers (in larger dwellings)
- A greater insulation thickness for the hot water cylinder
- Hot water cylinder with a quick recovery coil
- Thermostatic radiator valves
- Cavity wall insulation
- Insulated external doors (as replacements)
- More extensive use of insulated dry lining
- A greater thickness of insulation for dry lining
- Draughtstripping suspended timber ground floors and loft hatches

Table 2 Measures recommended for addition

- Internal or external wall insulation to existing cavity insulated walls
- Heat recovery ventilation
- Secondary glazing
- Glazing with low emissivity coating
- Reduction in thickness of flat roof or ground floor insulation to more cost-effective levels

Table 3 Measures not cost-effective in energy terms alone

The following reasons for not being able to implement all the recommendations were also given.

- ***Insufficient funding for the full package of measures.*** In four schemes, the improvement work was limited to the repair of single items, eg central heating or flat roof. Those housing associations that adopted an elemental approach to improvement said that many of the recommendations were likely to be included in future phases of their improvement work.
- ***Limited budget for shared ownership scheme.*** The association with the only shared ownership scheme in the study said that whilst funding was limited for that scheme, the specification of future projects had been improved as a result of the study.
- ***Doubts about condensing boilers.*** Several housing associations considered that condensing boilers were too new and complicated and therefore had higher maintenance costs. Past reliability was usually the prime consideration when selecting a particular model or make of boiler. However, when associations were asked which manufacturers' products had been most reliable, it was found that manufacturers on the approved list of some associations were on the blacklist of others. For information on condensing boilers, refer to EEO's Condensing Boiler Workshop manual[4] and BRE Digest 339[5].
- ***Boiler site-specific restrictions.*** Flueing for a specific model of condensing boiler was limited which meant that a suitable position for it could not be found within the dwelling. (This is not typical of all condensing boilers). A non-condensing, fan-assisted boiler of the same make with a wider range of flue options was substituted.
- ***Doubts about cavity wall insulation.*** Three housing associations did not specify cavity wall insulation for their schemes because of fears of rain penetration problems (see 4.3). Two of these schemes were near to the coast and consisted of three- or four-storey blocks of flats. In the third scheme, the outer leaf had numerous shrinkage cracks because of the use of calcium silicate bricks.

4.3 *The energy efficiency measures adopted*

For housing associations, simple payback was not the overriding criterion when determining whether a particular improvement measure should be adopted. Their main approach was to select tried and tested energy efficiency measures in order to improve the dwelling to a standard equivalent to the 1990 Building Regulations. In several design and build tenders, U-values were specified for walls and roofs in preference to forms of construction.

The uptake of the following energy efficiency measures is shown in table 4, by dwelling type.

Cavity walls

There were wide differences of opinion about cavity wall insulation. A few associations were reluctant to use it for fear of potential rain penetration problems, despite very low failure rates reported in a national BRECSU survey. Guidance on suitability for cavity wall insulation is available in EEO Good Practice Guide 26[6] and BRE Good Building Guide 5[7]. Most associations, however, were enthusiastic about its installation because they recognise it as a very cost-effective way of improving energy efficiency.

Solid walls

Adding an insulated dry lining was the most popular method of insulating solid brick walls. Insulation-backed plasterboard was the most common type of product used, incorporating extruded polystyrene, urethane foam or mineral wool insulants. Several housing associations increased the thickness of the insulated dry lining following the results of the SAP analysis, which showed that the payback periods for 50 to 65 mm thick composite boards were no greater than for 30 to 40 mm thick boards.

Roof insulation

All uninsulated pitched roofs were insulated with either 150 or 200 mm of mineral wool. Where there was existing loft insulation, it was usually less than 80 mm thick. This was topped up to provide a minimum overall thickness of 150 mm.

	Solid walls		Cavity walls	
	Houses	Flats	Houses	Flats
No of schemes	5	5	5	8
Gas central heating	5	4	5	4 (1)
Condensing boilers	3	0	0	0
Electric heating	0	1	0	4
Roof insulation	5	5	5 (1)	7 (1)
Cavity wall insulation	0	0	2	6 (3)
Insulated dry lining	5	5	2	1
External insulation	1	1	0	0
Ground floor insulation	3	1	0	0
Double glazing	4	4 (1)	3	8 (2)
Draughtstripping	5	5 (1)	5 (2)	8 (1)
Heat recovery ventilation	0	1	0	1
Passive stack ventilation	1	0	0	0

Note: brackets show improvements carried out previously.

Table 4 Summary of scheme energy efficiency measures by house type

Ground floors

In most schemes, the existing ground floors were left uninsulated, in particular for concrete ground floors. Where the ground floor was insulated, a wide range of techniques was used. These included:

- placing rigid insulation below a new concrete ground floor being installed as a replacement for an existing suspended timber floor
- insulating between the floor joists of a suspended timber ground floor above a cellar
- laying chipboard/insulation composite flooring panels on the concrete ground floor of a basement flat.

Windows

Double glazing with draughtstripping and trickle ventilation was specified as standard for all replacement windows, except in one scheme. This was in a listed building for which the replacement windows were exact copies of the originals. Secondary glazing was specified for this building.

In one scheme, a proprietary system was used to add a second pane of glass to existing single glazed windows. This cost, about the same as secondary glazing, was considerably cheaper and less disruptive than installing replacement windows. It was considered a success by both the housing association and its tenants, although it was not cost-effective in terms of energy efficiency.

Most of the replacement windows had PVC-U frames, since the main reason for specifying replacement windows was to reduce future maintenance.

Low emissivity glazing, although not cost-effective at current prices, was proposed and fitted by a couple of housing associations.

Heating systems

Gas central heating was installed in 18 schemes. The remaining five schemes had electric heating. Fuel switching took place on two schemes, in both instances the switch being to gas heating – from electric off-peak heating in one case and from solid fuel in the other.

All the electrically heated dwellings consisted of small bedsits or one- and two- bedroom flats. Off-peak storage heaters were the primary heating source for the electrically heated flats. Although off-peak electricity is a more expensive fuel than gas, the higher fuel costs are partially offset by the higher gas standing charges and the annual maintenance cost for gas central heating.

In two schemes designed for young single people, electric heating was preferred to gas. The advantages of electric storage heaters were said to be lower maintenance costs, and 'background' heating which reduced the risk of condensation.

For flats with a design heat loss of about 1.5 kW or less, the SAP analysis showed that electric heating was comparable or cheaper than gas once the standing charges for both gas and off-peak were taken into account. Where the design heat loss was more than about 2.5 kW, running costs were lower with gas, even allowing for the higher standing charges and annual maintenance costs.

The CO_2 emissions for electric heating and hot water were about two and a half times more than an equivalent system using gas.

The BREDEM analysis showed that, compared with conventional fan-flued boilers, condensing boilers showed payback periods of 5 years or less when properties were over about 90 m^2 in area. However, before receiving the BREDEM analysis and the recommendations, only one housing association had specified a condensing boiler.

As a result of the BREDEM analysis, this increased to four associations, although one later reverted to using a fan-flued boiler (see 'Boiler site-specific restrictions' in 4.2). In the three schemes where a condensing boiler was used, the dwellings were three-storey houses with floor areas between 110 and 160 m^2.

Combination boilers were commonly used for one- and two-bedroom flats and bungalows, instead of a separate boiler and hot water cylinder.

Hot water cylinders with quick recovery coils and at least 50 mm of factory-fitted insulation were recommended and sometimes fitted. Primary pipework was insulated in all schemes.

Ventilation
In the majority of schemes, humidistat-controlled extract fans for kitchens and bathrooms were specified; in one scheme of two-storey houses, a 'passivent' system was installed.

Two schemes opted for whole dwelling mechanical ventilation with heat recovery. These installations were not cost-effective in terms of energy savings, but were specified primarily to reduce the risk of condensation. Evidence from site visits suggested that tenant advice is needed on using the system correctly if it is to perform as intended.

Low energy lighting
Most associations installed standard or compact fluorescent lighting in communal areas, although very few specified low energy lighting inside dwellings. The one notable exception specified compact fluorescent lighting throughout the dwelling, including cupboards, even though cost-effectiveness dictates their use only in well-used areas such as living rooms, kitchens, hallways and communal areas.

4.4 Costs of energy efficiency measures
The housing associations supplied costs of the energy efficiency measures from the tender documents of the successful contractors.

In many cases, the cost of insulation was itemised separately and was therefore easy to identify. In other instances, such as the cost of double glazing in replacement windows, the insulation measure was not itemised separately, but included in other associated work.

In order to overcome this problem a number of contractors agreed to supply a more detailed breakdown of their costs, and one association put alternative clauses into the bills of quantities.

There was a reasonable consistency in the cost of most insulation measures between schemes.

Typical costs are given in table 5.

Construction and condition	Improvement measures	Typical cost (£/m²)	Typical payback period (years)
SOLID BRICK WALLS			
– good plaster finish	Add a 50 mm thick insulated dry lining, either:		
	during full refurbishment, or	20	10 – 12
	to improved property, including removing and refixing central heating, wiring, kitchen and bathroom fittings.	40	20 – 24
– plaster finish needs replacing	Renew with 50 mm thick insulated dry lining in place of uninsulated plaster finish	12*	6 – 8
– suffering from rain penetration	Add external insulation under new render finish	25 – 50	15 – 30
CAVITY BRICK WALLS			
– suitable for cavity fill	Blow or pump in cavity wall insulation	2 – 5	3 – 4
– unsuitable for cavity fill	Add an insulated dry lining as for solid walls	20	16 – 18
PITCHED ROOFS			
– no existing insulation	Add 150 or 200 mm loft insulation	2.50 – 5	2 – 3
– 50 mm existing insulation	Top up with 100 mm loft insulation	2 – 3	5 – 7
– 100 mm existing insulation	Not cost-effective to top up insulation	–	–
– room-in-the-roof design	Add 50 mm semi-rigid mineral wool slabs between rafters when re-roofing, or	3	2
	Use a 50 mm thick insulated dry lining when renewing plaster finish, **or**	12*	6 – 8
	Use 75 mm thick rigid urethane foam between and over rafters when re-roofing	12*	6 – 8
FLAT ROOFS	Add rigid insulation board to achieve U-value of about 0.35 W/m^2K	12 – 15	20 – 25
GROUND FLOORS			
– timber suspended (inc. floors over passageways)	Add 100 mm insulation quilt between joist if access is possible	6.50	13 – 15
– solid concrete	Lay chipboard/50 mm extruded polystyrene on existing floor	24	50
WINDOWS	When windows are being renewed, specify that double glazing, draughtstripping and trickle vents be incorporated	25*	12 – 15
– windows in good condition	Add secondary glazing	80	30 – 45
EXTERNAL DOORS		**(£)**	
– door in good condition	Add draughtstripping	14	5 – 10
– door needs renewing	Consider specifying an insulated door	50*	10

Table 5 Summary of tender prices for energy efficiency measures

*Extra cost, compared with alternative

Costs for ventilation and low energy measures were as follows.

- On one scheme of two-storey houses, a passive ventilation system cost over £600 more than installing two extract fans.
- The cost of mechanical ventilation with heat recovery ranged from about £500 for a small bedsit flat to £1300 for a two-bedroom flat.
- The extra cost of using compact fluorescent lighting throughout the dwelling averaged about £28 per fitting.

4.5 Technical risks and buildability issues

The following issues concerning technical risks and buildability were identified during the site visits.

Cavity wall insulation

To minimise technical risks, some associations insisted on a comprehensive inspection of the wall cavities (recommended good practice) and a schedule of any remedial work that was necessary. This schedule was prepared by the manufacturer of the cavity insulation and was either included in the tender documents or provided when remedial work was required. In the latter case, a provisional sum was included in the tender to cover such work. Once the approved installer had completed the cavity wall insulation, the manufacturer provided a guarantee against problems from rain penetration.

Insulated dry lining

In Victorian properties, it was usual to remove the existing plaster and fix the insulated dry lining on dabs. Not all installers were aware that to limit air infiltration there was a need to provide continuous ribbons of plaster adhesive around the perimeter of the wall linings and at openings.

Where existing plaster finishes were retained, it was more usual to fix the dry lining with a thin bed of adhesive.

Thinner dry lining boards, usually of 25 mm overall thickness, were used at window reveals and soffits to avoid masking the window frame. In one scheme, where metal replacement windows had been installed a few years earlier, less than 25 mm of frame was visible internally, making it impossible to accommodate an insulated lining.

Loft insulation

Where insulation was more than 150 mm thick, it was usually laid in two layers and cross-lapped to avoid thermal bridging at ceiling joists.

Ground floor insulation

In one scheme the contractor, having been given the option of placing the insulation above or below a new ground floor slab, chose to use underslab insulation. Insulation to the edge of the slab, although included in the specification, had been omitted on site.

Insulating a suspended timber ground floor was easy and cost-effective where there was sufficient space to give easy access from below, eg from a cellar. Where there was a shallow sub-floor void, insulation was only included in those schemes where tenants were decanted, because of the need to lift the floorboards.

Composite chipboard/insulation panels were used only in two basement flats. Two buildability issues arose. In one scheme, where the existing screed had been removed, a thin levelling screed was necessary to give a smooth, level surface for the insulation. In the other scheme, where insulation panels were laid over the existing floor, the trimmed doors appeared to be very short.

•	Wall insulation: – cavity fill – 50 mm insulated dry lining
•	Roof insulation: – minimum 150 mm in loft – insulation-backed plasterboard for sloping room-in-the-roof ceiling – 0.35 W/m^2K maximum U-value for flat roof
•	Double glazing with 12 mm air gap in replacement windows
•	All windows, doors, loft hatch and timber ground floors draughtstripped
•	Gas central heating: condensing boiler for dwellings over 100 m^2
•	Hot water cylinder with high recovery coil and minimum 40 mm thick factory-applied foam insulation
•	Extract fans to kitchen and bathroom
•	Trickle vents to windows
•	Cellar ceilings insulated with 100 mm insulation

Table 6 Recommended packages of improvement measures

4.6 A green approach to refurbishment

There was evidence in a few specifications of a 'green' approach, which included the selection of materials with reduced environmental impact.

- A proprietary insulation made from recycled newspaper was specified for the insulation of cellar, ceiling and loft spaces.
- Mineral wool was used for dry lining in preference to foamed plastics.
- Specifications required the use of CFC- and HCFC-free insulants.

4.7 Setting energy efficiency targets

The target most commonly used by housing associations when carrying out improvement work was the insulation standard of the 1990 Building Regulations. Consequently, the level of energy efficiency achieved by the improved properties tended to be as a result of the specification used, rather than of a target energy rating.

A few housing associations had started to use computer programs to produce energy ratings for their improvement schemes. It was not common practice, however, to use the energy rating programs as a means of setting and achieving an energy target, or of comparing the cost-effectiveness of alternative measures.

4.8 Recommended packages of measures for typical dwelling types

There was a high degree of uniformity in the improvement measures adopted for properties undergoing full refurbishment. Table 4 sets out the uptake of individual measures for the 23 schemes in the project. If housing associations were to use the recommended packages of improvement measures in table 6 as a starting point for their schemes, they would find that they achieve SAP ratings of 65 or more for the majority of their properties.

Table 6 assumes that gas is used for heating. Where gas is available, it will normally give lower running costs than electricity for dwellings with two or more bedrooms. For smaller dwellings, off-peak electricity is competitive with gas once the high standing charges and maintenance costs of gas systems are taken into account. Where electric storage heaters are installed, the package should include: 200 mm of insulation to pitched roofs; automatic charge control on storage heaters; fan-assisted storage heaters in large rooms; and hot water cylinder with minimum 50 mm thick factory-applied foam insulation.

5 CONCLUSIONS

Most housing associations in the study had proposed a high level of specification. In about half the schemes, recommendations were made that would improve the SAP rating by four points or more. In six schemes the omission of some items that were not cost-effective was recommended.

The average SAP rating for the properties undergoing full modernisation or refurbishment was 31 before improvement, and 72 after. About 80% of the dwellings analysed achieved a SAP rating of 65 or more following improvement work. SAP targets based upon floor area are more realistic than a single rating, because of the difficulty of some smaller dwellings cost-effectively achieving as high a standard as larger ones.

The thermal requirements of the 1990 Building Regulations were the most commonly accepted standard against which to judge a scheme's performance. Although housing associations said that the main purpose of improving thermal performance was to provide affordable warmth for their tenants, they saw energy ratings as simpler and more easily understood targets than 'affordable warmth'.

A wide range of techniques was used in the study, but there was still a reluctance to use some of the most cost-effective recommendations. A number of housing associations would not use cavity wall insulation because of a fear that rain penetration may occur. For others, condensing boilers needed to establish a good track record for reliability before being considered.

In contrast, insulated dry linings were widely used and accepted, but were not always installed correctly. The continuous ribbon of adhesive at the wall perimeter around openings, needed to minimise air infiltration, was frequently omitted on site.

Based upon this study, and other BRECSU experience on housing refurbishment, Good Practice Guide 155, *Energy efficient refurbishment of existing housing*, has been published. It gives detailed recommendations on selecting a package of improvement measures and includes comments on buildability issues and a specification checklist. Additionally, the Housing Corporation has now adopted minimum SAP targets essential for refurbishment of housing association dwellings. These standards are based principally upon analysis of the improved SAP ratings as depicted in figure 6. Table 7 shows the new refurbishment standards alongside the newbuild standards as specified by the Corporation's Scheme Development Standards[8].

SAP standards				
Floor area (m^2)	Newbuild SAP		Refurbishment SAP	
	minimum	recommended	minimum	recommended
35 and below	71	77	56	62
>35 to 40	72	78	57	63
>40 to 45	73	79	58	64
>45 to 50	74	80	59	65
>50 to 55	75	81	60	66
>55 to 60	76	82	61	67
>60 to 65	77	83	62	68
>65 to 70	78	84	63	69
>70 to 75	79	85	64	70
>75 to 80	80	86	65	71
>80 to 90	81	87	66	72
>90 to 100	82	88	67	73
>100 to 110	83	89	68	74
>110 to 120	84	90	69	75
Above120	85	91	70	76

Table 7 Housing Corporation SAP standards

References

1 **Department of the Environment** Energy Efficiency Best Practice programme Energy efficiency in new housing: Affordable new low energy housing for Housing Associations. Future Practice Research and Development 2, BRECSU, December 1992.

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4 **Department of the Environment** Energy Efficiency Best Practice programme Condensing boiler workshop manual, BRECSU, 1995.

5 **Building Research Establishment,** Condensing boilers, BRE Digest 339, CRC, 1990.

6 **Department of the Environment** Energy Efficiency Best Practice programme Cavity wall insulation in existing housing. Good Practice Guide 26, BRECSU, October 1995.

7 **Building Research Establishment,** Choosing between cavity, internal and external wall insulation. Good Building Guide 5, CRC, 1995.

8 **Housing Corporation,** Scheme Development Standards, ISBN 0 901454 67 2, August 1995.

APPENDIX – Addresses of participating associations

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Cheshire WA14 1EP

Beacon Housing Association
Arbor Hill House
39 Windsor Road
Slough Berks
SL1 2DR

Circle 33 Housing Trust
152 Blackhorse Road
London E17 6NH

County Palatine Housing Society
Burnleigh
82 Railway Road
Leigh Lancs WN7 4AN

Devon & Cornwall HA Limited
Uplands
81 Heavitree Road
Exeter Devon
EX1 2LX

Haig Homes
Alban Dobson House
Green Lane Morden
Surrey SM4 5NS

Heantun Housing Association
3 Wellington Road
Wellington House
Bilston
West Midlands
WV14 6AA

Leicester Newarke
Housing Association
11 Welford Road
Leicester LE2 7AD

MOAT Housing Society Ltd
St John's House
Suffolk Way
Sevenoaks Kent TN13 1TG

North Housing Association
Ridley House
Regent Centre
Gosforth
Newcastle-upon-Tyne
NE3 3JE

North Sheffield Housing
Association
91 Spital Hill
Sheffield S4 7LD

Notting Hill Housing Trust
26 Paddenswick Road
London W6 0UB

Orbit Housing Association
44-45 Queens Road
Coventry CV1 3EM

Peabody Trust
45 Westminster Bridge Road
London SE1 7JB

Ridings Housing Association
264a Roundhay Road
Leeds LS8 5RL

Shape Housing Association
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B5 6HF

Swaythling Housing Society
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